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DRYING BEHAVIOUR OF SECOND-GROWTH NOTHOFAGUS ALPINA

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ABSTRACT

Wood drying quality and transversal permeability of Chilean second-growth *Nothofagus alpina* (raulí) were evaluated. Two charges of raulí sawnwood were dried in a experimental kiln. One of the charges was prepared with sawnwood from Pinto the second one was prepared with sawnwood from Collipulli. The transverse permeability to air of the material after drying was determined. The results showed that the drying rate was 25% higher and drying time was about 18% shorter for Collipulli sawnwood (from green to 12%) due to the extent of heartwood. The shrinkage, collapse and drying stress were less in the wood dried from Collipulli, while the transverse permeability was lower in the samples from Pinto.

Keywords: Drying quality, permeability, raulí, collapse.

INTRODUCTION

Nothofagus alpina (raulí) is a very important Chilean native species with nice, even-textured grain, somewhat similar to the New Zealand silver beech (*Nothofagus menziesii*) but with a more pronounced reddish-brown hue (Olson 2003). Because of its high value, raulí was excessively exploited in the past and now accounts for only some 10% of the total cut of Chilean hardwoods. However, there are now about 1.2 Mha of productive regrowth of *Nothofagus spp*., much of it raulí (CONAF 1999, Gezan[3]). This resource is now being studied to evaluate the potential of the second-growth wood as raw material for furniture and other high-value end use. An important aspect of these studies concerns the determination of drying schedules and the drying behaviour.

INFOR (1990) explored possibilities of potential uses of second-growth raulí on the basis of the physical and mechanical properties. INFOR (1994) showed that second-growth raulí is relatively easy to dry with about to 6% of total volumetric shrinkage and air pre-drying times from 90 to 150 days. The drying time ranged from 8 to 37 days for 25 and 50 mm thick respectively (INFOR 1994, 1997). Ananías *et al*. (1994) showed that freshly-cut wood had a superior permeability and a somewhat larger drying rate than stored wood, but its total drying time was longer due to the higher initial moisture content. They also determined that wood quality after drying was generally better in fresh second-growth raulí. In addition, they found more permeability in fresh samples and also they noted that permeability to air and water are of the same order as predicted by theory (Siau 1995). When the dry wood was checked for quality, the fresh wood had less cup and and crook but more twist and checks (Ananías *et al*. 1994).

The present study was undertaken to investigate the drying behaviour of 50mm boards of second-growth *Nothofagus alpin*a and examine possibilities of improving the quality of drying.

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MATERIALS AND METHODS

Sixty experimental trees were harvested in a regrowth forest of *Nothofagus alpina* (Poepp et. Endl.) taken from near Collipulli (IX Region of Chile) and near Pinto (VIII Region of Chile). Sampling of the trees was undertaken according to Chilean Standard NCH 968 (INN 1986).The characteristics of the logs are showed in Table 1.

Table 1: Logs characteristics of second-growth raulí (*Nothofagus alpina*)

Trees	Diameter (cm)	Nº growth annual rings	Basic density (kg/m^3)
Collipulli	23 (8)	48 (6)	500 (40)
Pinto	34 (4)	75 (6)	500 (40)

n=30, (standard deviation)

180 boards of nominal dimensions 50x125x1800 mm were prepared, three per tree, and distributed at random into two lots for drying and permeability tests. For drying, the first lot was prepared from Collipulli trees whereas the second lot was prepared from Pinto trees. The sawnwood was dried in a vapor-heated experimental kiln of 0.25 m^3 capacity with an air-circulation velocity of 2.5 m/s. The drying schedule was adopted from INFOR (1994). The dry-bulb temperature rose from 48 to 80 ºC and the wet-bulb temperature varied from 46 ºC to 58 ºC at the end. At the beginning, a pretreatment at 80 ºC in a saturated atmosphere was given for eight hours. At 18 % moisture content, the charges were reconditioned for six hours under the same conditions. At the end the dried wood was conditioned at 80 ºC for eight hours in a saturated atmosphere. The moisture content of each charge was determined at appropriate times by weighing three sample boards of 0.5 m length and confirmed by oven-drying small sections. The shrinkage and collapse were evaluated according to Chilean Standard NCH 176/3 (INN 1984) and the moisture gradient and drying stresses calculated as shown by Welling (1994).

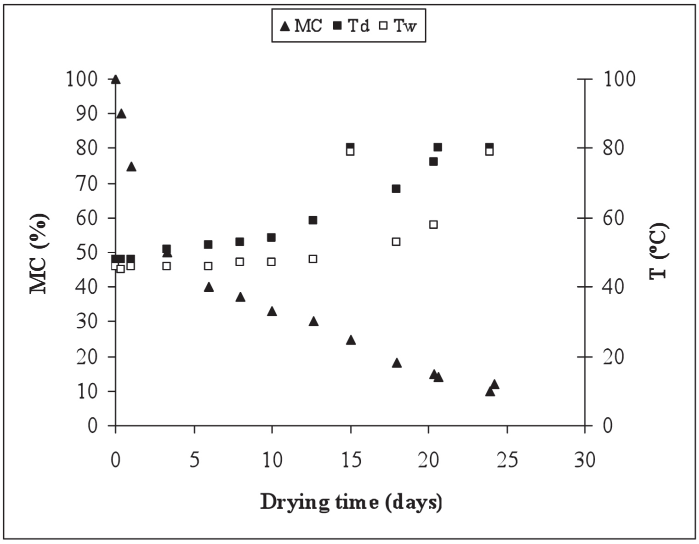
Air-permeability measurements were made on specimens prepared after conditioning to 12 % moisture content. Sampling and conditioning was carried out in accordance with the Chilean Standard (INN 1986). The permeability of the material was measured on cylindrical specimens of 76 mm diameter and 6 mm length in the radial and tangential direction, respectively, using an apparatus described by Kauman *et al*. (1994). The specimens were held against a seat in the permeability cell by a strong spring and a secure seal was achieved by an O-ring. Specific permeability was calculated by means of Equation 1 (Siau 1995).

$$K_G = \frac{Q_G \cdot L \cdot P}{A \cdot \Delta P \cdot P'} \cdot \eta \qquad (1)$$

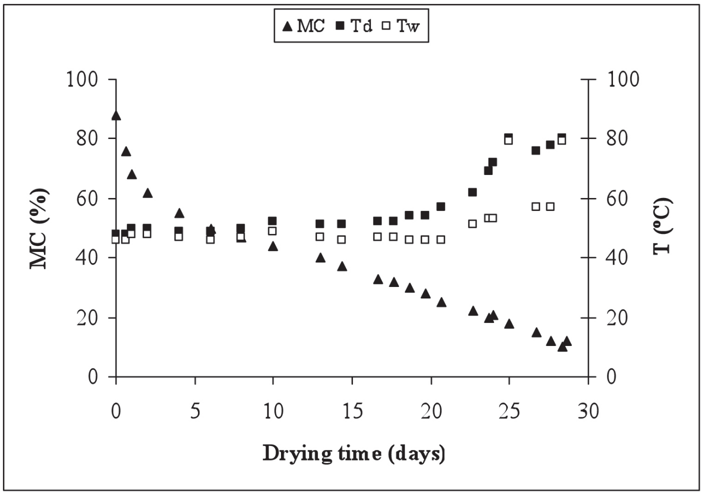
where K_G is the specific permeability of air in m^2, Q_G the flow rate in m^3/s, L the flow length in m, P is the pressure in Pa at which the flow Q is measured, A the flow area in m^2, ΔP the pressure drop in Pa, P' the mean absolute pressure within the specimen in Pa, and *n* the viscosity in Pa.s.

RESULTS AND DISCUSSION

Figure 1 shows the drying curves for the two drying runs. The drying rates were approximately 25% faster in sawnwood from Collipulli, as the run from Pinto took about 18% longer to dry. This difference is due to the effects of the characteristics of the trees (Table 1), there being a larger diameter and more annual growth rings with the trees from Pinto. This may suggest more extensive heartwood in this material, as observed before (INFOR 1994).



a) Raulí from Collipulli



b) Raulí from Pinto

Figure 1: Drying curves of second-growth raulí (*Nothofagus alpina*)

Table 2 gives the shrinkage and collapse estimated as proposed by INN (1984). The overall shrinkage and collapse were lower for material dried from Collipulli. This may be due to greater drying stresses in material dried from Pinto (Table 3).

Table 2: Wood drying shrinkage and collapse of second-growth raulí (*Nothofagus alpina*)

Wood samples	Transversal shrinkage (%)					
	B.R. at 18 % MC		A.R. at 18% MC		A.R. at 12% MC	
	Radial	Tangential	Radial	Tangential	Radial	Tangential
Collipulli	2.0 (0.3)	3.6 (0.4)	1.8 (0.2)	3.1 (0.4)	2.7 (0.4)	4.6 (0.6)
Pinto	3.0 (1.0)	4.2 (1.3)	2.5 (1.0)	3.9 (1.3)	3.9 (1.1)	5.9 (1.2)

n=15, (standard deviation), B.R.: before reconditioning, A.R.: after reconditioning

Table 3: Moisture content, moisture gradient and drying stresses of second-growth raulí (*Nothofagus alpina*)

Wood samples	Moisture content (%)			Drying stresses (mm)
	Initial	Final	Final gradient	
Collipulli	100 (14)	12 (2)	2 (3)	1 (2)
Pinto	89 (7)	12 (2)	2 (4)	2 (3)

n=12, (standard deviation)

However, these second-growth raulí are faster to dry and have less shrinkage and collapse than when virgin Chilean coigüe is dried (Kauman and Mittak 1964).

Table 4 shows the results for flow rate and air permeability. The flow rate and permeability to air were higher in wood from Collipulli. This may be related to the less extensive heartwood with smaller-diameter trees and narrower annual growth rings (Table 1). The air permeability in these experiments was of the same order that the water permeability of second-growth raulí (Ananias *et al*. 1994). It is 100 times lower than observations on tepa *Laurelia philippiana* (Kauman *et al*. 1994). This difference may be a reflection of the very fine structure of raulí. The air permeability of second-growth *Nothofagus alpina* was also lower by a factor of 10 than observations on sapwood of New Zealand red beech *Nothofagus fusca* (Kininmonth 1971).

Table 4: Transversal flow rate and air permeability of second-growth raulí (*Nothofagus alpina*)

Wood samples	$Q_G x10^8$ (m^3/s)		$K_G x10^{18}$ (m^2)	
	Radial	Tangential	Radial	Tangential
Collipulli	29.2 (12.1)	27.6 (15.9)	7.5 (1.0)	3.8 (0.3)
Pinto	9.8 (6.8)	4.7 (5.2)	3.1 (0.4)	1.7 (0.7)

n=16, (standard deviation)

The flow rate and permeability were smaller in the Pinto specimens, due to the more extensive heartwood in this material. As the drying rates were also lower in these specimens (Figure 1 a y b), it may be surmised that the rate-controlling mechanism was diffusion and not permeability. This hypothesis would, however, need to be confirmed by independent measurements.

CONCLUSIONS

Kiln drying of 50 mm second-growth raulí with a schedule starting at 48 ºC dry bulb temperature and rising to 76 ºC at the end of drying took 25 days from green (100%) to 12% moisture content. The quality of drying was satisfactory when the boards were from sourced from Collipulli but not quite as good when they were from Pinto. In addition, there was some collapse in the Pinto material, while the drying time was 18% longer due to the more extensive heartwood. The small permeability of the raulí specimens suggests that diffusion is the controlling mechanism.

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